NAVAL POSTGRADUATE SCHOOL
Monterey, California

EC 3550 FINAL EXAM 12/96 Prof. Powers

- This exam is open book and notes.
- There are four problems; each is equally weighted.
- Partial credit will be given; be sure to do some work on each problem.
- Be sure to include units in your answers.
- Please circle or underline your answers.
- Show *ALL* work.
- Write only your name on this sheet.
- Exams and course grades *should* be available outside the Optical Electronics Laboratory (Bu 224) on **Thursday afternoon, 19 December**.
- Have a good holiday season and enjoy your break!

Course grade: _____

1		3	
2		4	
TOTAL			

Name: _____

FIBER SPECIFICATIONS

	Fiber #1	Fiber #2	Fiber #3	Fiber #4
Size	50/125	62.5/125	10/125	100/140
g	1.90	∞	∞	1.78
NA	0.22 (at $r = 0$)	0.20	0.09	0.18 (at $r = 0$)
α @ 850 nm	2.0 dB/km	1.0 dB/km	1.2 dB/km	5.0 dB/km
α @ 1300 nm	1.0 dB/km	0.8 dB/km	0.7 dB/km	2.0 dB/km
α @ 1550 nm	0.6 dB/km	0.4 dB/km	0.4 dB/km	0.8 dB/km

SOURCE SPECIFICATIONS

	Laser #1	Laser #2	LED #3	Laser #4
Wavelength	850 nm	1300 nm	850 nm	1550 nm
$\Delta\lambda$	0.5 nm	1.0 nm	25 nm	1.1 nm
Power at pigtail end	0.70 mW	0.8 mW	60 μW	2.0 dBm
Pigtail size	62.5/125 μm	10/125 μm	200/300 μm	8/125 μm
Pigtail NA	0.20	0.12	0.25	0.10
Pigtail type	Step index	Step index	Step index	Step index

DETECTOR SPECIFICATIONS

	Detector #1	Detector #2	Detector #3
Material	Silicon	Germanium	InGaAs
Responsivity A/W @ $M = 1$	0.8 @ 850 nm	0.2 @ 1300 nm 0.3 @ 1550 nm	0.3 @ 1300 nm 0.45 @ 1550 nm
C_d	3 pF	1 pF	2 pF
Excess noise factor	$M^{0.3}$	M^{1}	$M^{0.6}$
Bulk dark current	0.10 pA	1 μA	0.1 μA
Surface dark current	0	1 nA	0

IMPORTANT: Specifications of numbered components are shown in the tables.

1. Consider the fiber local-area network shown in the figure. Assuming that the fiber losses are negligible and that the connector losses are 1 dB per connection, calculate the link margin from laser #1 to receiver #A. The insertion loss of a coupler is 1 dB larger than the splitting loss of the coupler. The power required at the receiver to achieve the desired bit-error rate is $P_R[\text{dBm}] = -60 + 12\log(B_R'[\text{Mb/s}])$. The allowance for aging is 3 dB. [**Announced during exam: The link operates at 55 Mb/s.**]

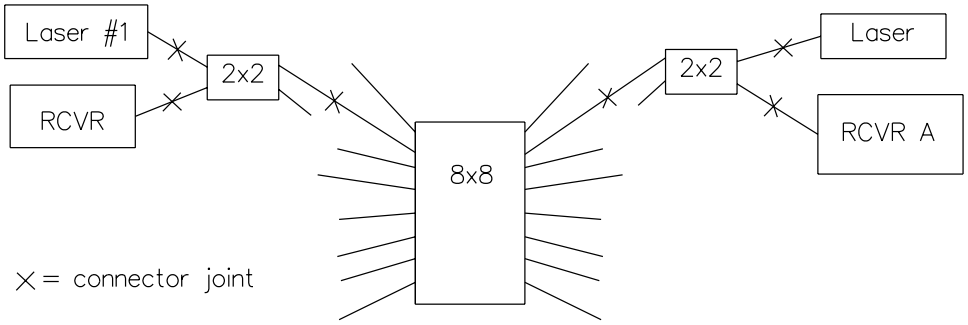

Figure 1: Local area network for Problem 1.

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2. Consider fiber #1. Find the ratio of the material-dispersion limited distance to the modal-dispersion limited distance at $\lambda = 850$ nm if $n_1 = 1.47$. [**Announced during exam: Assume that the source is LED #3.**]

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3. Consider APD detector #2 operating at 1300 nm into a load resistor of 500 Ω at a noise temperature of 350K. When connected to a preamplifier with a 20 dB gain and when the optical power at the receiver is 10 nW, it is observed that the optimum value of the APD gain is 12. Calculate the noise figure of the amplifier *in dB*.

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4. Consider detector #3 operating as a pin diode at 1550 nm into a load resistor of 1 kΩ. Assuming that the noise is dominated by the shot noise associated with the bulk dark current of the detector, find the optical power that is required at the receiver to achieve a BER of 10^{-12} at a bit rate of 100 Mb/s.